Product Service

Test Report No.64.290.23.30407.01

Dated 2023-04-14

Client:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. The 1st and 2nd floors of the workshop in Zone 2 No. 58, Longzhou West Road Longjiang Town Shunde District, 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Manufacturer:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. The 1st and 2nd floors of the workshop in Zone 2 No. 58, Longzhou West Road Longjiang Town Shunde District, 528318 Foshan City, Guangdong Province PEOPLE'S REPUBLIC OF CHINA
Manufacturing place:	Guangdong Lesso Banhao New Energy Technology Group Co., Ltd. Plot A-2, South side of Longjiang Dachong, beside Chanxi Avenue, Longjiang Town, Shunde District, 528000 Foshan City, Guangdong Province, PEOPLE'S REPUBLIC OF CHINA
Test subject:	Product: Photovoltaic modules
Test specification:	IEC 61853-1:2011 IEC 61853-2:2016 IEC 60891:2009
Purpose of examination:	PAN File Parameters Determination
Test result:	The test results for the present samples are show in clause3

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1 Description of the test subject

1.1 Function

Manufacturer's specification for intended use:

The PV modules for electricity generation systems with max. voltage of 1500 V DC

1.2 Consideration of the foreseeable misuse

☒ Not applicable
☐ Covered through the applied standard
☐ Covered by the following comment
☐ Covered by attached risk analysis

1.3 Technical Data

Type or model number	545D(HPM)72(182)
Voc (Vdc)	49.62±3%
Vmp (Vdc)	41.80
Isc (Adc)	13.91±4%
Imp (Adc)	13.04
Pmp (W)	545
Bifaciality factor, if bifacial module	N/A
Power tolerance	±3%
Maximum system voltage (V)	1500
Maximum over-current protection rating (A)	25
Application Class	Class II

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2 Order

2.1 Date of Purchase Order, Customer's Reference

2023-02-10, 5779149

2.2 Receipt of Test Sample, Location

2023-03-14

Changzhou HuaYang Inspection and Testing Technology Co., Ltd.

No.8 Lanxiang Road, Wujin Economic Development Zone, Changzhou, Jiangsu, P.R.China

2.3 Date of Testing

2023-03-14 / 2023-04-08

2.4 Location of Testing

Changzhou HuaYang Inspection and Testing Technology Co., Ltd.

No.8 Lanxiang Road, Wujin Economic Development Zone, Changzhou, Jiangsu, .R.China

2.5 Points of Non-compliance or Exceptions of the Test Procedure

N/A

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3 Test Results

3.1 Sample Information

Sample #	Model	Sample S/N	Remark
1	545D(HPM)72(182)	BH1F61LAC230227031342	IEC 61853-1
2	545D(HPM)72(182)	BH1F61LAC230227031442	IEC 61853-1
3	545D(HPM)72(182)	BH1F61LAC230227031437	IEC 61853-1
			IEC 61853-2

3.2 Flash Tests According to Table 2 of the IEC 61853-1

To determine the relationship between efficiency and irradiance & temperature, PV modules are tested across a matrix of operating conditions according to the standard IEC 61853-1:2011, ranging in irradiance from 100 W/m^2 to 1100 W/m^2 and ranging in temperature from 15 °C to 75 °C.

To determine the temperature coefficients, PV modules are tested according to IEC 60891:2009, under irradiance 1000W/m^2 and ranging in temperature from 15 °C to 45 °C.

Based on the laboratory measurement data, PAN file can be optimized, then match ability between the resulting efficiencies in PVsyst software and the lab data can be compared.

3.3 Raw Data

TABLE 2:

Flash test data for each sample at the real irradiance and temperature conditions in table 2 of the IEC 61853-1

#1							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	47.200	41.954	1.362	1.285	53.929	83.89
15	200	48.487	42.231	2.766	2.634	111.252	82.94
15	400	50.615	43.020	5.506	5.324	229.021	82.18
15	600	50.644	43.627	8.351	7.915	345.299	81.64
15	800	50.887	43.813	11.122	10.507	460.343	81.34
15	1000	51.561	43.680	13.706	13.108	572.555	81.02
25	100	45.903	40.332	1.376	1.290	52.016	82.37
25	200	47.321	41.010	2.779	2.624	107.607	81.82
25	400	48.735	41.491	5.577	5.322	220.826	81.24
25	600	49.165	41.835	8.337	7.929	331.707	80.93

25	800	49.712	42.119	11.121	10.517	442.985	80.13
25	1000	50.177	42.045	13.776	13.110	551.209	79.74
25	1100	50.303	42.174	15.165	14.345	605.001	79.31
50	400	45.077	37.724	5.613	5.368	202.498	80.03
50	600	46.076	38.283	8.345	7.935	303.794	79.01
50	800	46.493	38.601	11.135	10.522	406.144	78.45
50	1000	46.952	38.545	13.891	13.114	505.475	77.50
50	1100	47.101	38.603	15.262	14.367	554.598	77.15
75	600	43.011	34.818	8.372	7.960	277.163	76.97
75	800	43.531	35.159	11.151	10.533	370.316	76.29
75	1000	43.810	35.102	14.010	13.119	460.518	75.03
75	1100	44.016	35.184	15.338	14.373	505.716	74.91

#2							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	46.921	41.639	1.377	1.304	54.285	84.04
15	200	48.454	41.966	2.771	2.663	111.748	83.22
15	400	50.651	42.815	5.478	5.354	229.228	82.62
15	600	50.327	43.795	8.362	7.882	345.204	82.03
15	800	50.901	43.613	11.101	10.564	460.734	81.54
15	1000	51.534	43.580	13.728	13.149	573.021	81.00
25	100	45.946	40.288	1.373	1.291	52.021	82.45
25	200	47.358	41.290	2.780	2.614	107.936	81.98
25	400	48.494	41.257	5.569	5.339	220.282	81.57
25	600	49.173	41.672	8.301	7.961	331.751	81.27
25	800	49.720	41.786	11.059	10.579	442.038	80.39
25	1000	50.039	41.611	13.791	13.231	550.563	79.78
25	1100	50.132	41.755	15.115	14.466	604.008	79.71
50	400	45.300	37.826	5.582	5.357	202.616	80.13
50	600	46.201	38.637	8.343	7.894	305.001	79.13
50	800	46.637	38.646	11.084	10.523	406.672	78.67
50	1000	47.053	38.484	13.873	13.159	506.406	77.58
50	1100	47.162	38.521	15.228	14.436	556.071	77.43
75	600	43.009	35.094	8.375	7.886	276.749	76.83
75	800	43.901	35.217	10.979	10.482	369.142	76.59
75	1000	43.987	35.347	13.900	13.016	460.079	75.25
75	1100	44.094	35.466	15.275	14.234	504.827	74.95

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#3							
T_{TARGET} [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Vmp [V]	Isc [A]	Imp [A]	Pmp [W]	FF [%]
15	100	47.130	41.741	1.375	1.297	54.138	83.57
15	200	48.195	41.952	2.788	2.647	111.026	82.63
15	400	50.569	42.692	5.536	5.368	229.157	81.85
15	600	50.715	43.276	8.341	7.962	344.551	81.45
15	800	50.892	43.382	11.163	10.604	460.040	80.98
15	1000	51.505	43.449	13.702	13.169	572.195	81.08
25	100	45.557	40.166	1.373	1.290	51.802	82.79
25	200	47.027	40.768	2.785	2.645	107.818	82.32
25	400	48.324	41.256	5.580	5.338	220.238	81.68
25	600	49.097	41.578	8.343	7.977	331.679	80.97
25	800	49.639	41.789	11.112	10.580	442.113	80.15
25	1000	50.035	41.778	13.801	13.176	550.484	79.72
25	1100	50.186	41.689	15.160	14.478	603.557	79.33
50	400	45.325	37.840	5.580	5.359	202.803	80.19
50	600	46.216	38.511	8.288	7.909	304.581	79.52
50	800	46.658	38.641	11.078	10.504	405.903	78.53
50	1000	47.115	38.619	13.824	13.104	506.058	77.70
50	1100	47.328	38.667	15.164	14.362	555.345	77.38
75	600	43.087	35.185	8.367	7.877	277.162	76.88
75	800	43.958	35.498	11.036	10.428	370.160	76.30
75	1000	44.102	35.370	13.873	13.034	461.026	75.35
75	1100	44.294	35.486	15.235	14.264	506.171	75.01

Table 3:

Temperature Coefficients Measurement Data at the 1000 W.m^{-2} Irradiance

#1				
T [ºC]	IRR_{TARGET} [W/m^2]	Voc [V]	Isc [A]	Pmp [W]
15.2	1000	51.561	13.735	573.055
20.2	1000	50.737	13.760	562.418
25.2	1000	50.177	13.776	551.209
30.1	1000	49.490	13.803	542.068
35.3	1000	48.855	13.819	533.211
40.3	1000	48.264	13.849	524.762
45.3	1000	47.633	13.860	514.413

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3.3.1 Test Data Analysis

3.3.1.1 Temperature Coefficients

Figure 1:

Plot of measured Voc vs. temperature of flash-tests taken at 1000 W/m^2 for sample #1

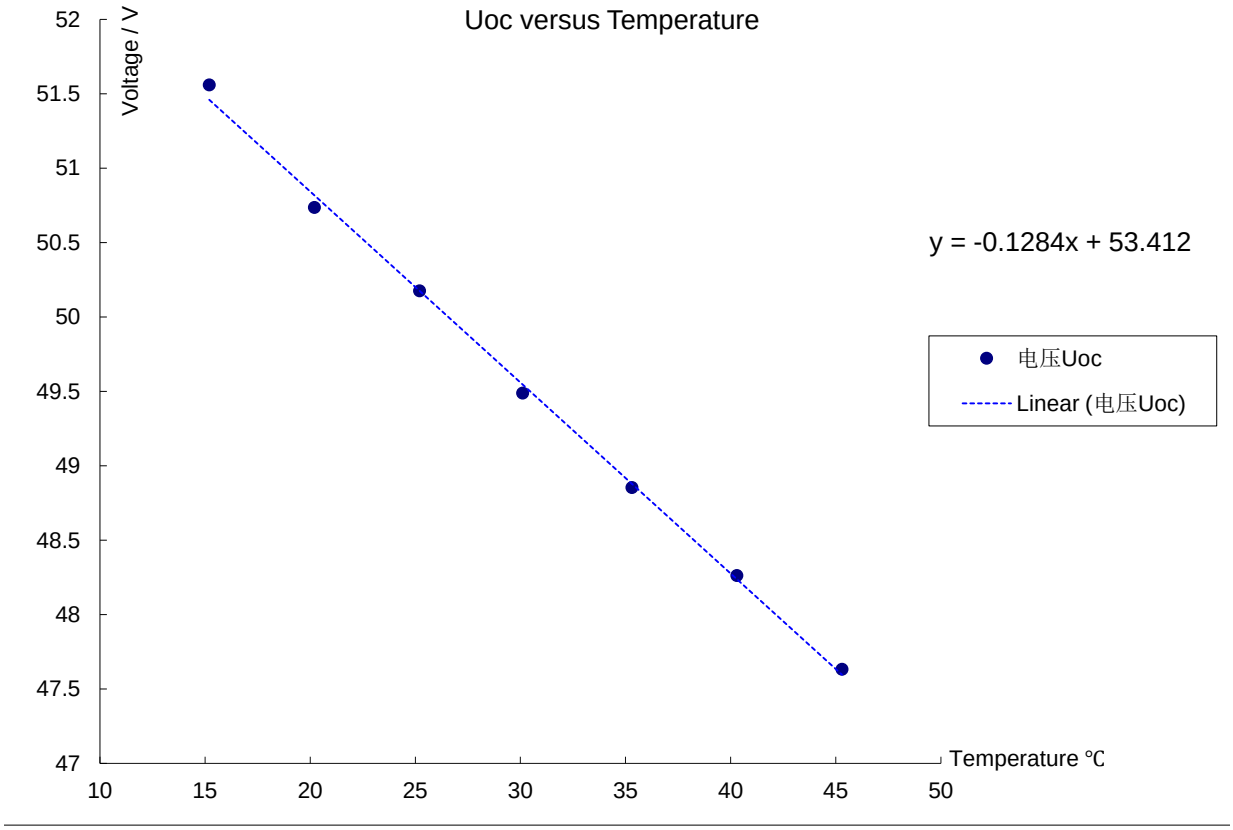

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Figure 2:

Plot of measured P_{MAX} vs. temperature of flash-tests taken at 1000 W/m² for sample #1

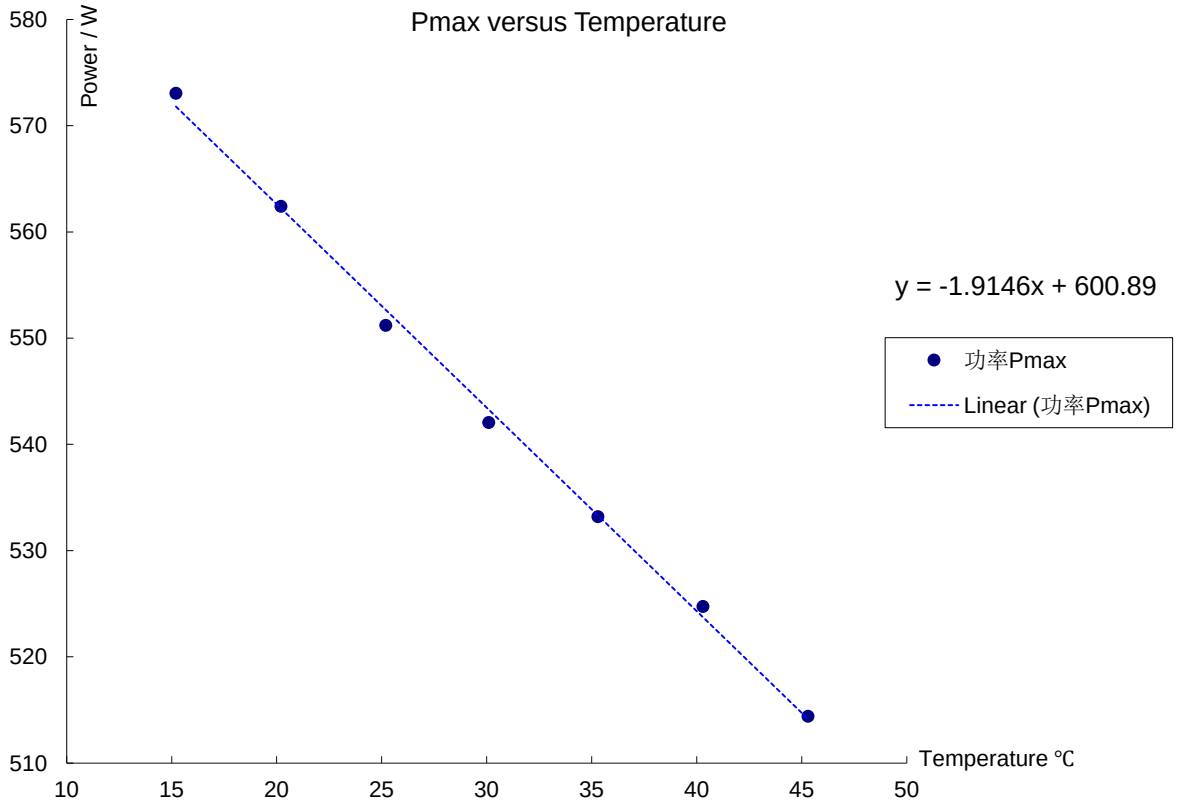

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Figure 3:

Plot of measured Isc vs. temperature of flash-tests taken at 1000W/m² for sample #1

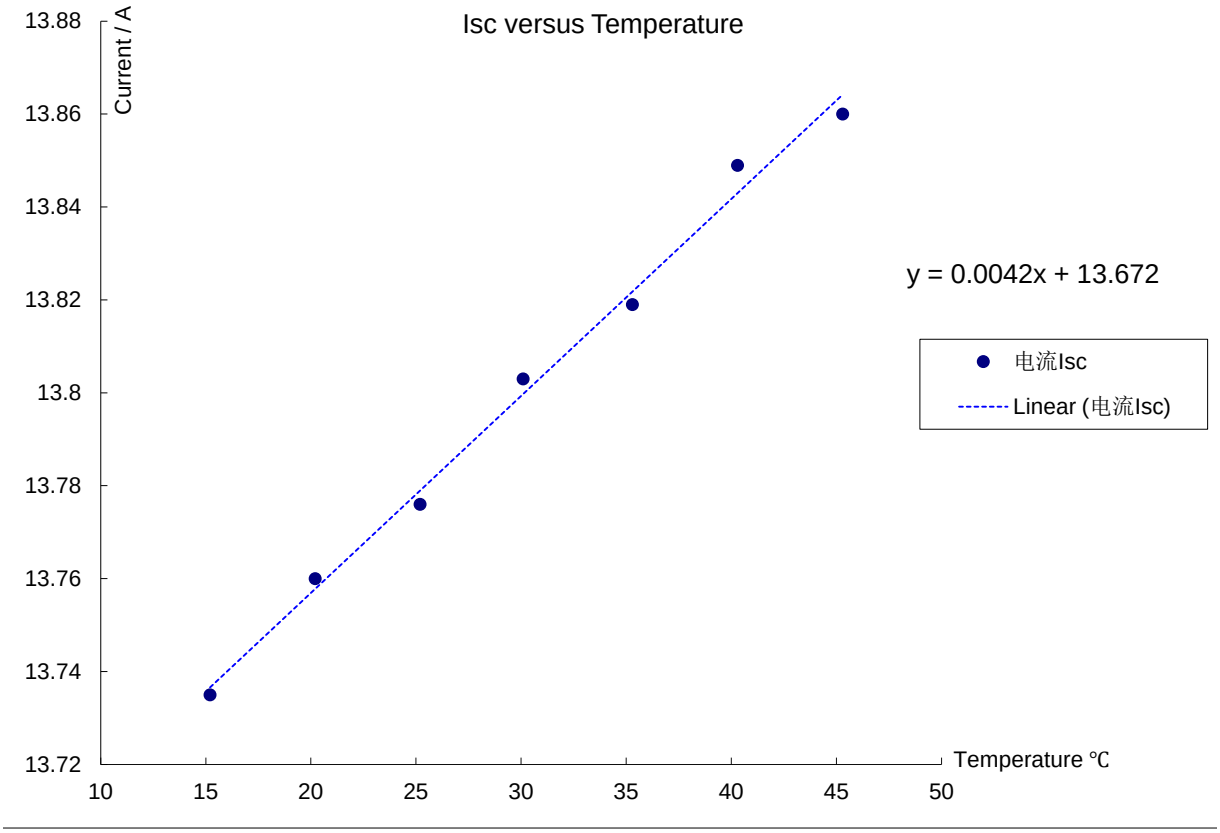

Table 4:

Average Temperature Coefficients Determined by Laboratory Results

Sample No	Alpha (α) ISC [%]	Beta (β) VOC [%]	Gamma (γ) PMAX [%]
#1	0.033	-0.254	-0.341

3.3.1.2 P_{MAX} vs. Irradiance & Temperature

Table 5:

Average P_{MAX} Determined by Laboratory Results according to the IEC 61853-1 based on Table 2

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m²]	Module Temperature			
	15 °C	25 °C	50 °C	75 °C
100	54.117	51.946	-	-
200	111.342	107.787	-	-
400	229.135	220.449	202.639	-

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600	345.018	331.712	304.459	277.025
800	460.372	442.379	406.240	369.873
1000	572.590	550.752	505.980	460.541
1100	-	604.189	555.338	505.571

Table 6:

P_{MAX} Determined by Laboratory Results Scaled to Nameplate Power at STC

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m²]	**Module Temperature**			
	15 °C	**25 °C**	**50 °C**	**75 °C**
100	53.552	51.404	-	-
200	110.179	106.661	-	-
400	226.742	218.146	200.523	-
600	341.415	328.248	301.279	274.131
800	455.564	437.759	401.997	366.010
1000	566.610	545.000	500.695	455.731
1100	-	597.879	549.538	500.291

Table 7:

Relative Efficiency by Laboratory Results Scaled to Nameplate vs. Irradiance at 25°C

Sample No	**Irradiance [W/m²]**						
	100	200	400	600	800	1000	1100
Average	94.32%	97.85%	100.07%	100.38%	100.40%	100.00%	99.73%

4 PAN File Creation

4.1 PAN File Creation Method

The PAN file contains a number of model parameters organized in different tabs within PVsyst. The parameters which affect the model results in forward bias (normal operation) are located in the tabs labeled “Basic Data” and “Model Parameters”. TUV-SUD’s approach to PAN file creation is as following:

1. Enter manufacturer specifications on the “Basic Data” tab;
2. Enter the relative efficiency test results in **Table 7**under different irradiance at 25°C into “Additional Data/Low-light data” , and optimized the Rserie; It is mentioned that the relative efficiency is calculated after scale the average measured P_{MAX} lab data from **Table 5** to the manufacturer’s nameplate power. The scaled data is shown in **Table 6** and **Table 7**.
3. Define the Rsh, Rsh0 and Rexp (on the “Model parameters” tab) for default values;
4. Enter the Pmax, Isc, Voc temperature coefficient in **Table 4** into “Model parameters” tab;

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4.2 Optimized PAN File Results

PV module - 545D(HPM)72(182)

Manufacturer	LESSO	**Commercial data**	
Model	545D(HPM)72(182)	Data source :	TUV SUD
Pnom STC power (manufacturer)	545 Wp	Technology	Si-mono
Module size (W x L)	1.134 x 2.278 m²	Rough module area (Amodule)	2.58 m²
Number of cells	2 x 72	Sensitive area (cells) (Acells)	2.38 m²

Specifications for the model (manufacturer or measurement data)

Reference temperature (TRef)	25 °C	Reference irradiance (GRef)	1000 W/m²
Open circuit voltage (Voc)	49.6 V	Short-circuit current (Isc)	13.91 A
Max. power point voltage (Vmpp)	41.8 V	Max. power point current (Impp)	13.04 A
=> maximum power (Pmpp)	545.1 W	Isc temperature coefficient (muIsc)	4.6 mA/°C

One-diode model parameters

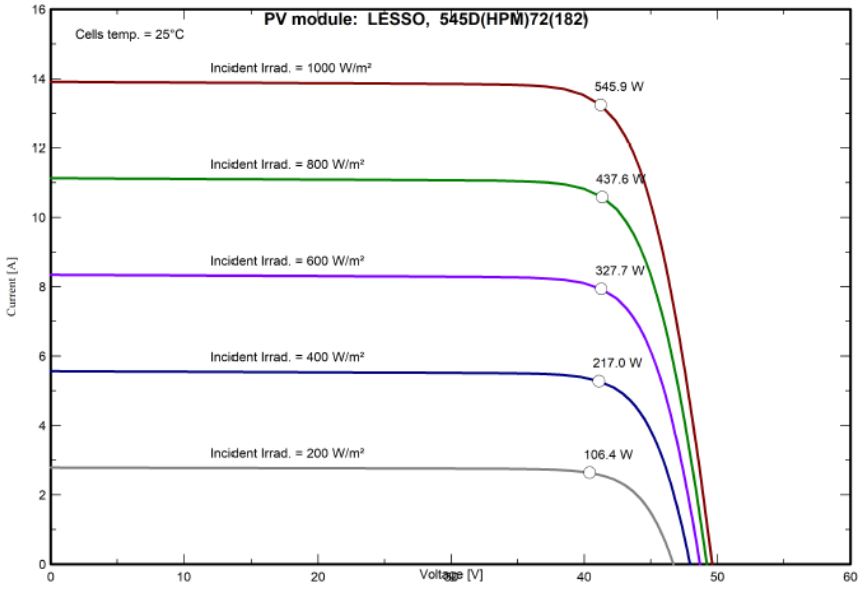
Shunt resistance (Rshunt)	500 Ω	Diode saturation current (IoRef)	0.016 nA
Serie resistance (Rserie)	0.20 Ω	Voc temp. coefficient (MuVoc)	-136 mV/°C
Specified Pmax temper. coeff. (muPMaxR)	-0.34 %/°C	Diode quality factor (Gamma)	0.98
		Diode factor temper. coeff. (muGamma)	0.000 1/°C

Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch

Reverse characteristics (dark) (BRev)	3.20 mA/V²	(quadratic factor (per cell))	
Number of by-pass diodes per module	3	Direct voltage of by-pass diodes	-0.7 V

Model results for standard conditions (STC: T=25 ° C, G=1000 W/m² , AM=1.5)

Max. power point voltage (Vmpp)	41.2 V	Max. power point current (Impp)	13.25 A
Maximum power (Pmpp)	545.9 Wp	Power temper. coefficient (muPmpp)	-0.34 %/°C
Efficiency(/ Module area) (Eff_mod)	21.1 %	Fill factor (FF)	0.791
Efficiency(/ Cells area) (Eff_cells)	22.9 %		



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4.3 PAN File Result Verification

After creating the PAN file, a quality check is implemented in order to compare the PAN file model consistence with measurements from the laboratory. The laboratory test results scaled are plotted as efficiency vs. irradiance curves for each temperature of the IEC61853-1 test matrix, as shown in **Table 8**. Similarly, efficiency vs. irradiance curves are generated using PVsyst and the newly created PAN file, as shown in **Table 9**. Comparison between the model and the measurements is represented with the following graph and table.

Table 8:

Efficiency Determined by Laboratory Results Scaled to Nameplate Power at STC

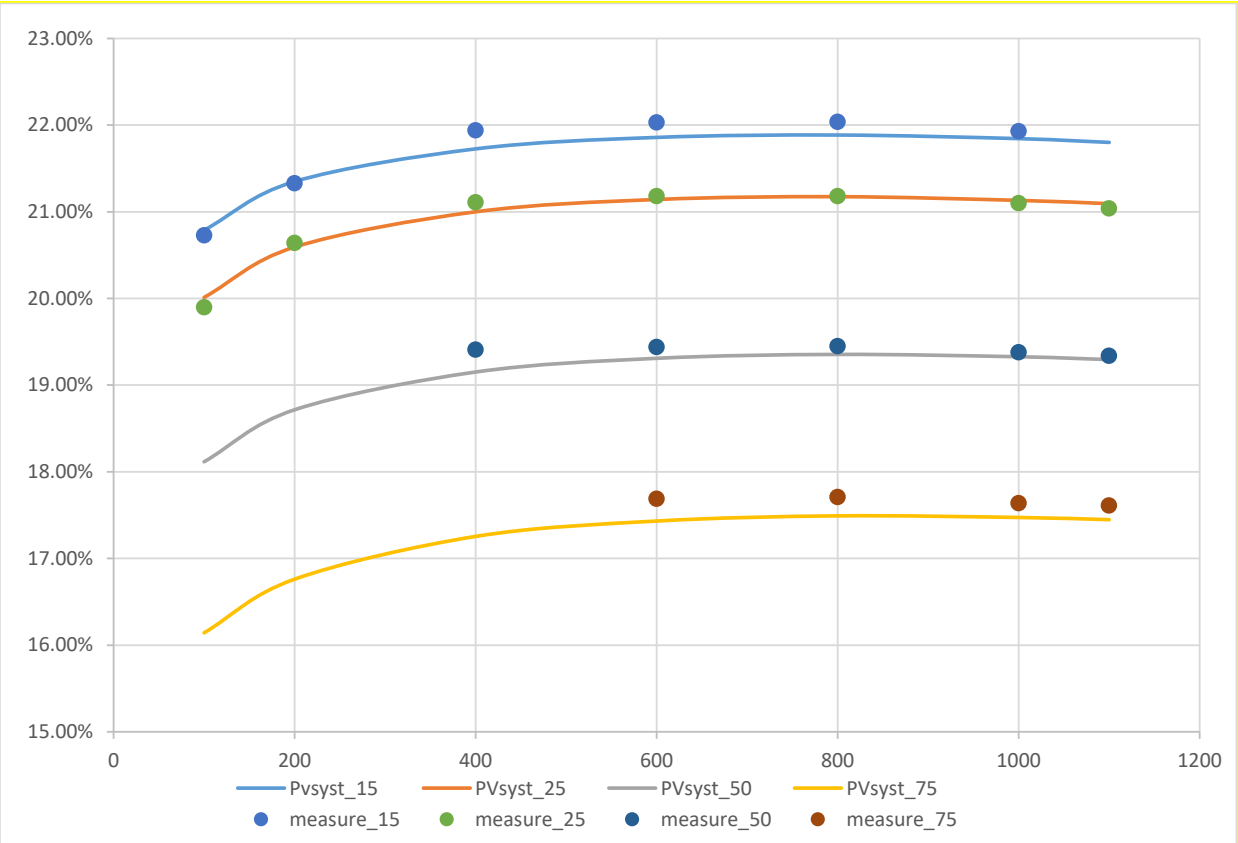
Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m²]	**Module Temperature**			
	15 °C	**25 °C**	**50 °C**	**75 °C**
100	20.73%	19.90%	-	-
200	21.33%	20.64%	-	-
400	21.94%	21.11%	19.41%	-
600	22.03%	21.18%	19.44%	17.69%
800	22.04%	21.18%	19.45%	17.71%
1000	21.93%	21.10%	19.38%	17.64%
1100	-	21.04%	19.34%	17.61%

Table 9:

Efficiency Generated Using PVsyst and the Newly Created PAN file.

Average Pmax [W] Results Acquired over Multiple Irradiances per Temperature				
Irradiance [W/m²]	**Module Temperature**			
	15 °C	**25 °C**	**50 °C**	**75 °C**
100	20.79%	20.01%	18.12%	16.14%
200	21.35%	20.59%	18.72%	16.76%
400	21.73%	21.00%	19.15%	17.26%
600	21.86%	21.14%	19.31%	17.43%
800	21.89%	21.17%	19.36%	17.49%
1000	21.84%	21.13%	19.33%	17.47%
1100	21.80%	21.09%	19.30%	17.45%

Figure 4:
Comparison of PVsyst Model, Using the Optimized PAN file, to the Laboratory Testing Results



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4.4 Measurement of incidence angle effects

Sample No	#3	—
Isc_80°/A:	1.885	—
Isc_-80°/A:	1.849	—
Isc_0°/A:	13.587	—
m=(Isc_80°/Isc_0°)/ cos 80°	0.799	—
n=(Isc_-80°/Isc_0°)/ cos 80°	0.784	—
DeviationΔ=|(m-n)/(m+n)|×100% ≤2%	1.0%	P

Module Angle	Im [A]	Vm [V]	Isc [A] (Average)	Voc [V]	P [W]	IAM value according to IEC61853-2	IAM value according to PVsyst
0	-	-	13.587	-	-	1.00	1.00
10	-	-	13.411	-	-	1.00	1.00
20	-	-	12.841	-	-	1.01	1.00
30	-	-	11.862	-	-	1.01	0.99
40	-	-	10.470	-	-	1.01	0.99
50	-	-	8.747	-	-	1.00	0.98
60	-	-	6.711	-	-	0.99	0.96
65	-	-	5.596	-	-	0.97	0.95
70	-	-	4.398	-	-	0.95	0.93
75	-	-	3.131	-	-	0.89	0.90
80	-	-	1.885	-	-	0.80	0.83
85	-	-	0.743	-	-	0.63	0.62

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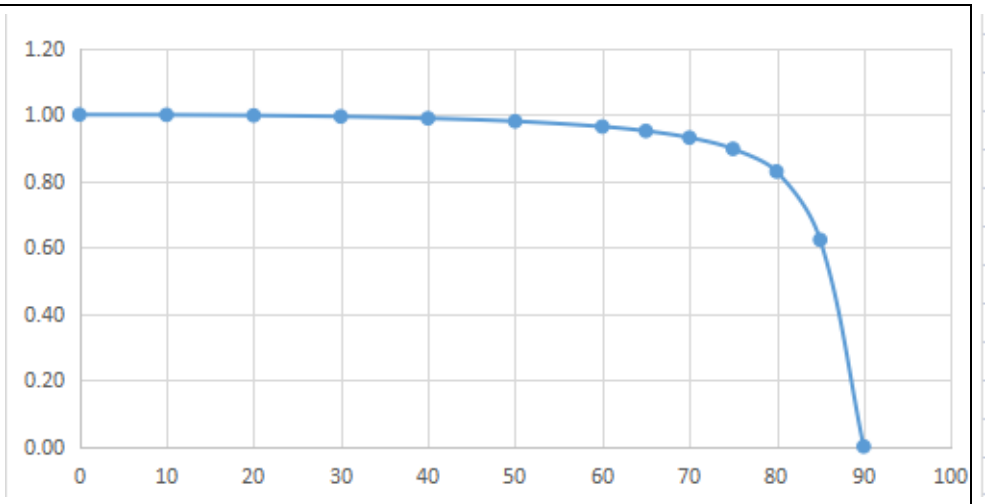
Fitted curve	 τ(θ) =1−bo×(1/cos(θ)−1) (formula according to PVsystem), b_0=0.036

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5 Documentation

Annex 1: PRODUCT DESCRIPTION SHEET (MANUFACTURERS AND TYPE REFERENCES)

A1.1	**MODULE TYPE/S**	
	545D(HPM)72(182)	
A1.2	**MODULE DESIGN –DIMENSIONS**	
	Module dimensions (L x W x H) [mm] .....:	2278 x 1134 x 35
A1.3	**SOLAR CELL**	
	Cell type reference .....:	Bifacial PERC Cell(T-V1), Cell type: 7M9E1018A-L1, 10BB Cell dimensions L x W: 182.0 × 91.0 ± 0.5(mm), Cell thickness: 185 ± 18.5 (μm), Zhejiang Aiko Solar Energy Technology Co., Ltd
A1.4	**IDENTIFICATION OF MATERIALS**	
	Front cover .....:	Material:Anti-reflective coating low iron patterend solar glass, Thickness: 2.0(mm), Xinyi Environmental Protection Special Type Glass (Wu hu) Co., Ltd.
	Rear cover .....:	Type: FFC-JW3010(Plus), Color: White, Total Thickness: 310 mm, Jolywood (Suzhou) Sunwatt Co., Ltd.
	Encapsulation material .....:	Type: F406PS (contact with front cover), Thickness: 0.55(mm), Hangzhou First PV Material Co., Ltd
		Type: F806PS (contact with rear cover), Thickness: 0.55(mm), Hangzhou First PV Material Co., Ltd
	Frame .....:	Material：6005 T6, Guangdong Lesso Banhao New Energy Technology Group Co., Ltd.
	Adhesive for frame .....:	Type: SMG533, Material:Silicon, white, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Cell connector.....:	Type: Tin-coated copper ribbon, Cross section: Φ=0.32 (mm), Xi'an Telison New Materials Co.,Ltd

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	String connector .....:	Type: Tin-coated copper ribbon, Cross section: 0.45 x 4 (mm) & 0.35 x 6 (mm), Xi'an Telison New Materials Co.,Ltd
	Junction box .....:	Type: PV-JB12x, Suzhou UKT New Energy Technology Co., Ltd.
	Potting material.....:	Type: SKF323, Material:Silicon, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Adhesive for junction box .....:	Type: SMG533, Material:Silicon, white, GUANGZHOU BAIYUN CHEMICAL INDUSTRY Co., Ltd.
	Cable .....:	Type H1Z2Z2-K 1×4mm^2, WUXI XINHONGYE WIRE & CABLE CO., LTD.
	Connector .....:	Type: CO02, Suzhou UKT New Energy Technology Co., Ltd.
	Bypass diode .....:	Type: TM3045-25, Suzhou UKT New Energy Technology Co., Ltd.

Annex 2: List of measurement equipment

Description	Type/ Equipment ID	Calibration due date	Remark
Pulsed Solar Simulator	HYJC-YS-021	2024.01.04	-

Annex 3: Statement of the estimated uncertainty of the test results

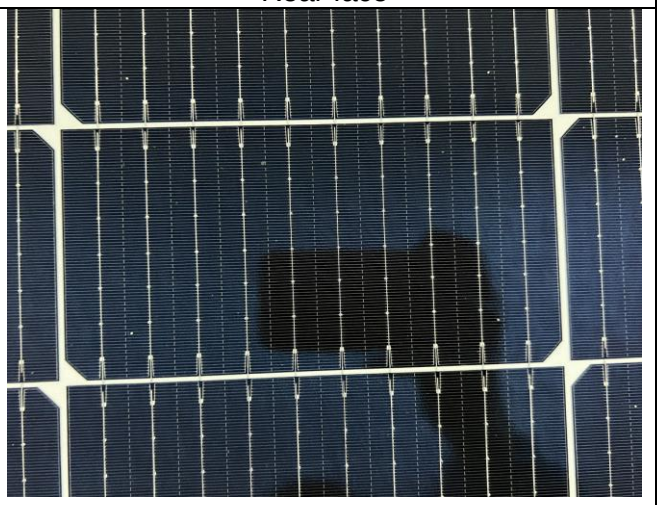
Pmax measurement uncertainty: 2.16% (K=2) Voc measurement uncertainty: 1.00% (K=2) Isc measurement uncertainty: 2.40% (K=2)

Annex 4: Picture of the module

Front face

Rear face

Nameplate



Solar cell

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6 Summary

Below parameters are measured on three representative PV modules:

- The relative efficiency test results under different irradiance at 25°C
- Performance at the real irradiance and temperature conditions in table 2 of the IEC 61853-1

Based on the test results, PANFILE are optimized in Pvsyst. Efficiency vs. irradiance curves are generated using PVsyst and the newly created PAN file, which is highly matched with the test results in lab.

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Tested by: Catherine Shu

Catherine Shu, Project Handler

Approved by: Tom Cai

Tom Cai, Designated Reviewer

--- End of Report ---

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